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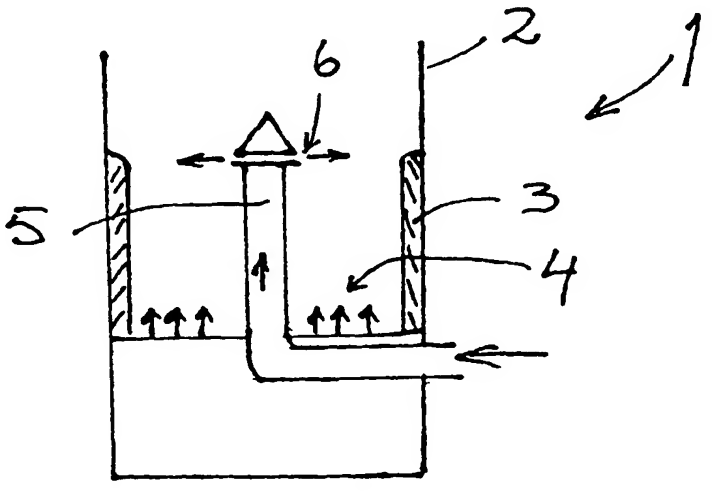
(54) Title: METHOD FOR BURNING MATERIAL IN A FLUIDIZED BED BOILER



(57) Abstract: The invention concerns a method for the combustion of material in a fluidized-bed boiler and the fluidized-bed boiler (1). The boiler possesses a combustion chamber in the conventional way, into which is fed combustible materials, primary air from beneath and also secondary air to maintain the combustion. Secondary air is conveyed into the boiler along a duct which is essentially central with respect to the cross section (5) of the boiler and the secondary air thus introduced is blown via nozzles (6) at the end of the duct towards the walls of the boiler.

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Method for burning material in a fluidized bed boiler

The present invention relates to a method for the combustion of material in a fluidized-bed boiler and the fluidized-bed boiler for this purpose.

Fluidized-bed combustion has rapidly gained in popularity during the past fifteen years. Boilers were originally constructed mainly for the combustion of coal and their use for the combustion of refuse and biomass began later.

Coal combustion releases a minimal amount of pyrogenic gases compared to that in biomass combustion and thus the regulations for boiler construction are different.

Initially the boilers were the so-called ebullating-bed boilers, in which a satisfactory retention time for coal combustion was not achieved unless the coal was very finely ground. Later the so-called circulating-bed boilers, in which the bed-sand is circulated via various dust-collectors and separators back to the flotation chamber, became prevalent. Thus the retention time for the burning coal can be extended.

The combustion benefit ratio for circulating-bed boilers is significantly better than that for ebullating-bed boilers. Their disadvantage is, however, the need for large and expensive separation devices, e.g. cyclones. The size of their separation devices and return devices is almost in the same class as that of the actual boiler and the price is 20-60% of the actual boiler's price.

In all boilers, the return-air intake is divided into several and generally into at least two zones, namely the primary and secondary air-feed zones.

It has been shown in many studies that it is advantageous, at least in the case of fuels which are rich in vaporizable substances, to feed the secondary return air relatively low down, immediately above the expanding bed.

Maximum retention time for the fuel is advantageous, as has been shown, but the

prior art in circulating bed boiler constructions always demands space and separation devices requiring large differential pressure. Large differential pressures also lead to large energy requirements (fan-energy).

The blowing of air into the central areas of the boiler is known from EP publication 0073650. According to this publication, it is always a question of the concurrent feeding of both air and solid particles along inlet ducts. In a system according to the present application, the feeding of solid particles is accomplished by alternative means and, according to the invention, the inlet ducts feed only air.

EP Patent 0 281 165 B1 presents a fluidized-bed boiler for the combustion of coal, and particularly for the combustion of poor quality coal, in which a level bottom hearth is divided by a barrier into parts. Secondary air is fed into the boiler from numerous nozzle-holes in this barrier at a height which is at least one meter from the base of the boiler but no more than 30% of the boiler's total height. The barrier covers 40-75% of the boiler's basal surface area. A solid material separator and solid material return are also used in this boiler for the combustion gases and this is described as a circulating-bed boiler according to the main claim and description section.

The invention attempts to introduce combustion air in two stages and utilize the floor-dividing "wall" of the combustion chamber as an extra heat-exchanger, so that the temperature of the lower part of the fluidized-bed chamber would not rise excessively. According to the example in the patent, the "wall" introduced 36% of the secondary air and 14% of the total air. The boiler was designed for the combustion of coal, and heat was collected from the wall in the form of steam which comprised 5% of the total amount of steam. The proportion of secondary air to the total air was 54%.

The Finnish patent 100064 describes how fluidization air is introduced under higher pressure from the center of the fluidization base than from the sides, as a result of which internal circulation and cooling are accomplished. In the same patent, the secondary air is made to circulate above the fluidization chamber, as a result of which the cooling effect is intensified. This construction is also suitable for

coal combustion, in which vaporizable substances are known to be few.

Finnish patent application 962585 (Combustion Engineering) deals with an internal circulation fluidized-bed construction, characterized in that the overturning of the fluidized sand is accomplished through the use of inclined walls, in which case the combustion material, preferably bio-fuel, waste and sludge, is fed in between the first actual and the overturned layers.

The lower fluidized-bed chamber is divided into several different zones, into each of which air is introduced from its own air distribution unit. Thus circulation is achieved which travels the length of the inclined floor, as mostly fluidized-bed air is blown in at the lowest part of the inclined floor and the inclined wall which is above this section overturns the risen fluidized-bed to the opposite side, between which the fuel is introduced.

In the alternative embodiment described in the above patent application, the fuel is introduced centrally between the said layers by the use of horizontal inlet screws.

Ebara Corporation's US Patent 5,682,827 presents a construction similar to the previous one, in which there is also internal circulation, which is accomplished by means of two different floor inclinations and also in which the fuel is introduced centrally from above, descending onto the fluidized-bed sand.

In U.S. Patent 5,138,982, it is shown that cooling pipes are fitted at the edges of the internal circulation, and that the internal circulation on the fluidized-bed is achieved by means of inclined external walls, in the same way as in the Finnish application 962585.

U.S. Patent 4,879,958 presents the accomplishment of internal circulation by means of an arced "reflector surface" centrally over the bed, which returns the sand and fuel particles which strike it and in which the upper section of the arc contains secondary air openings. The upper part also functions as a pre-heater for the fluidized-bed air. Preheating is performed by pipes constructed into the upper part from which air is introduced pre-heated to the fluidized-bed.

The purpose of this invention is to accomplish a method and a boiler which are particularly well suited for the combustion of easily vaporizable fuels and by means of which the benefits of the circulating-bed boiler are obtained with the most advantageous use of its own energy. According to this invention, a simple, extended pre-heating system for secondary air has also been created.

The invention is now described in more detail with reference to the attached patent drawings in which certain embodiments of the invention are presented in simplified figures.

Thus:

Figure 1 shows a furnace according to this invention viewed in cross section;

Figure 2 shows an alternative embodiment to the embodiment shown in figure 1;

Figure 3 shows the cross section A-A in figure 2;

Figure 4 shows a lateral view of another alternative embodiment;

The method and boiler according to this invention are illustrated in the following description.

The basic idea of the invention is that internal circulation is brought about with the aid of secondary air. According to the invention, secondary air is introduced symmetrically from the center of the combustion chamber advantageously by jet-flow, so that the secondary air blows the fluidized fuel particles and finer sand close to the side, where it falls down. In this way a circulating-bed boiler is achieved without the many expensive and complex structures which are typical of the circulating-bed boilers which are currently in use.

Figure 1 shows a simplified illustration of one embodiment of this invention diagrammatically in vertical section. The boiler is indicated by reference number 1. Because other parts consist of conventional technology, illustration of the air-feed

according to the invention is given priority. Accordingly, only the boiler's lower parts are shown in figure 1.

Boiler 1 has, in the conventional way, a shell 2 and a brickwork lower section, which in the presented embodiment also continues some way up the lower part of the boiler wall. The brickwork of the wall is marked with reference number 3. Primary air is fed into the boiler from beneath. The flow of the primary air is marked with the arrows 4. The feed devices are omitted from the drawings for the sake of clarity. In addition, the boiler contains a pipe-like component 5, which brings secondary air for the combustion event. The pipe 5 naturally originates from outside the boiler, continues beneath the hearth and through this, rising essentially centrally into the combustion chamber.

The upper end of the pipe-like secondary air-feed device 5 contains suitable nozzles 6, via which secondary air is blown into the interior of the boiler approximately horizontally or directed slightly downwards. This is illustrated by means of arrows in the upper part of pipe 5. The purpose of the air flow is also to initiate a circulatory motion within the boiler so that the air and, with it, a portion of the fluidized sand and combustible material will circulate, extending the time during which the material remains within the combustion chamber. The circulatory motion is such that the majority of the downward flow travels close to the wall 3.

Figure 2 shows, as in figure 1, an alternative embodiment of the invention, which contains more or less the same elements as figure 1, but now the pipe-like device 5 for conveying the secondary air serves also as an effective heat exchanger, in that there are now many pipes conveying secondary air. These are marked with the reference numbers 51 in figure 2 and also in the cross-section in figure 3. The pipes 51 are especially bunched together within the shell of pipe 5. Reference number 52 indicates the fluidization nozzles, the purpose of which is to keep the internal part of pipe 5 clean of accumulated material such as ash, etc. By means of this structure, secondary air is heated effectively as it flows upwards through the pipework. Under certain circumstances the shell pipe 5 can be omitted.

Figure 4 shows yet another alternative boiler according to this invention. In this

there are heat exchangers 7 fitted close to the boiler walls 2 which can be of the superheater radiator type. In this case, there remains a duct between the boiler wall and the radiator, into which the airflow from the secondary air nozzles 6 is mainly directed. This is believed to have the effect of strengthening the circulation.

Because the large volume of vaporizing components of bio-fuels demands much secondary air and little primary air, it is advantageous to utilize little high-pressure primary air and as much as possible lower pressured secondary air. This also results in the fuel remaining longer in a fluidized state, because the fluidization velocity remains low.

Because the lower part of the boilers are generally always bricked or ceramically formed into an adiabatic unit, it is advantageous to extend this layer at least to the level at which the secondary air is introduced, so that the still unburnt particles which are blown to the sides receive the maximum possible heat radiation. This arrangement functions even more advantageously if there are no upwardly blowing nozzles near to the side in the fluidization floor, but the floor is either free of nozzles at a distance of 20-40 cm from the wall of the boiler, or the nozzles and floor are in this part inclined towards the center.

The conveyance of secondary air into the boiler by such nozzles in which the gas is introduced in as even a zone as is possible but at the same time contains as much transportation energy as possible is the most advantageous solution.

The device 5 for introducing secondary air can be, as previously described, a cylindrical horn, pipe or a square device, fitting into the boiler shape in the middle of the combustion chamber, in the upper end of which are horizontal or slightly downwards directed nozzle openings 6. Alternatively the device 5 for the introduction of secondary air can be a heat exchanger formed from many air conveying pipes 51, which pre-heats the secondary air and in the upper end of which the air from the different pipes is combined and introduced, via a slit nozzle, into the boiler.

The nozzles 6 are advantageously located at a height at which the suspension

density of the fluidized-bed has been reduced to less than half the suspension density on the bed floor.

This solution is particularly advantageous together with such a fluidized-bed arrangement as is described in this application's parallel application, the name of which is "Floor structure of a fluidized-bed boiler."

An advantageous ratio of secondary air and primary air is, depending upon the fuel, 1:4.5. An advantageous pre-heating temperature for the secondary air is between 250-450°C. An advantageous velocity for the secondary air at the nozzle slot is 20-50 m/s. All in all, the nozzle slot's circumferential length is advantageously between 0.1-0.25 of the total length of the boiler's external wall.

When the primary fluidization air's rising velocity is normally 0.7-3.0 m/s, the secondary air's transfer energy ratio to the transfer energy of the fluidization air is between 400-10,000. The basis of this calculation is in this case the relative amount to the power of the square of the velocity ratio.

In many fluidized-bed boilers, there are separate heat exchangers within the fluidization chamber itself or over it, separate from the membrane wall. One embodiment of this invention can be regarded as the following arrangement in which superheater radiators, for example, are placed close to the wall, though sufficiently separated from it, as previously described, and that secondary air is blown behind the radiators and close to the wall, thus causing the solid particles to fall back into the dense fluidization chamber proper.

The invention is described above by means of several preferred embodiments. It is clear, however, that these are by no means intended to restrict the invention; rather it can be adapted in many ways without deviating from the breadth of the basic inventive idea and the protection of the accompanying patent claims.

Claims

1. A method for the combustion of material in a fluidized-bed boiler, in which there is a combustion chamber into which is fed combustible material, primary air from beneath and also secondary air from a duct which is essentially central with respect to the boiler's cross-section, and in which the secondary air thus conveyed is blown via nozzles at the upper end of the duct towards the walls of the boiler, **characterised** in that the secondary air is blown into the combustion chamber at a height at which the suspension density of the fluidized-bed is less than half of the suspension density at the bed floor.

2. A method according to claim 1, **characterised** in that secondary air is blown into the combustion chamber at a height at which the suspension density of the fluidized-bed is less than 0.2 times the suspension density at the bed floor.

3. A method according to claim 1, **characterised** in that secondary air is blown essentially horizontally or in a slightly downward inclined direction towards the walls of the boiler.

4. A method according to claim 1, **characterised** in that secondary air is conveyed to the boiler along many essentially central pipes.

5. A method according to any of the previous claims, **characterised** in that the secondary air is pre-heated within the duct in which it is conveyed.

6. A method according to any of the previous claims, **characterised** in that the kinetic energy of the secondary air is, at the impingement site of the primary and secondary air, 100-10,000 times greater than the kinetic energy of the rising primary air, advantageously between 500-700.

7. A method according to any of the previous claims, **characterised** in that secondary air is blown into the boiler at a 1-4.5 times greater volume than that of the primary air.

8. A fluidized-bed boiler, in which there is a combustion chamber, a device for the feeding of combustible material into the chamber, fluidization nozzles or similar devices for the conveyance of primary air into the combustion chamber from beneath, and devices for the conveyance of secondary air into the combustion chamber such that they form a duct which is essentially central with respect to the cross section of the boiler (5), at the end of which are nozzles (6) for the blowing of secondary air via the nozzles towards the walls of the boiler, **characterised** in that the nozzles (6) are located at a height at which the suspension density of the fluidized-bed is less than half the suspension density above the floor of the boiler (1).

9. A boiler according to claim 8, **characterised** in that secondary air nozzles (6) are located at a height at which the suspension density of the fluidized bed is less than 0.2 times the suspension density of the bed floor.

10. A boiler according to claim 8, **characterised** in that the duct (5) is formed of many separate pipes (51) in which the conveyed secondary air is advantageously pre-heated to a temperature of 250-450°C.

11. A boiler according to claim 8, **characterised** in that the boiler (1) also contains, at a distance from the inner wall, a protective device such as a heat exchanger (7), in which case at least a proportion of the blown-in secondary air is directed through the duct between the heat exchanger (7) and the inner wall.

12. A boiler according to any of the claims 8-11 **characterised** in that the circumferential length of the nozzle slit (6) is 10-25% of the circumferential length of the boiler's internal wall.

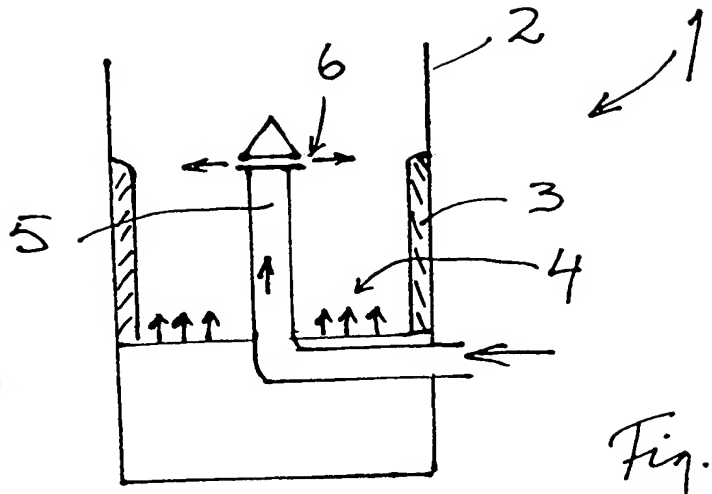

Fig. 1

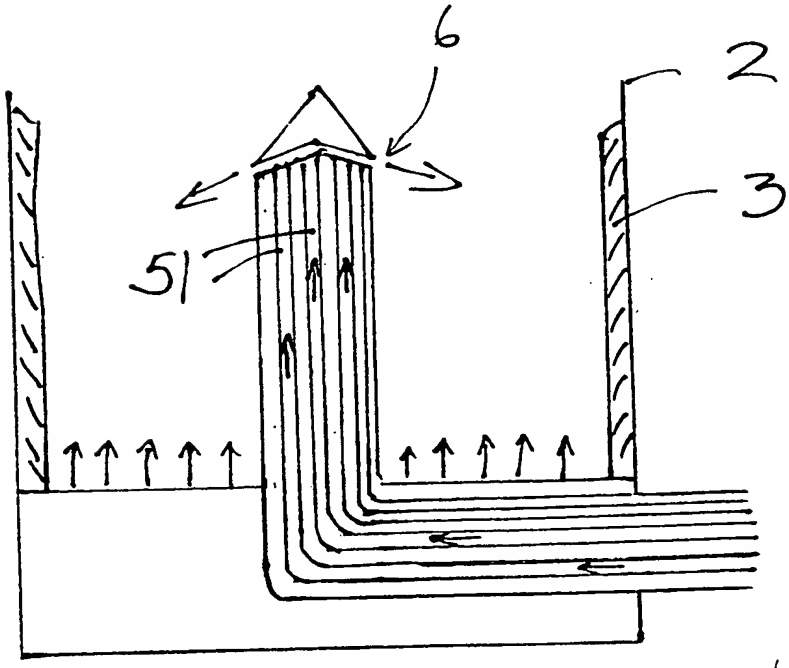

Fig 2

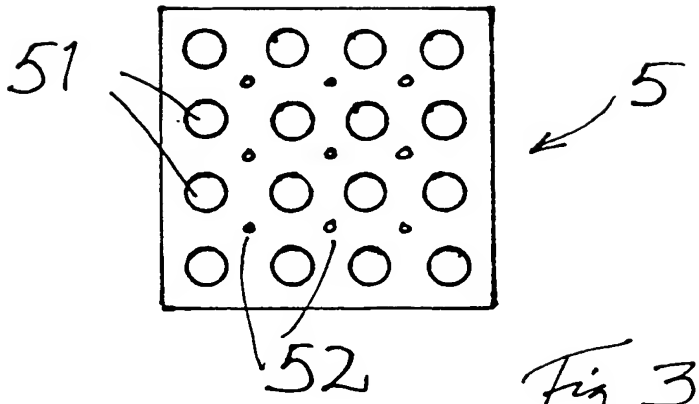

Fig 3

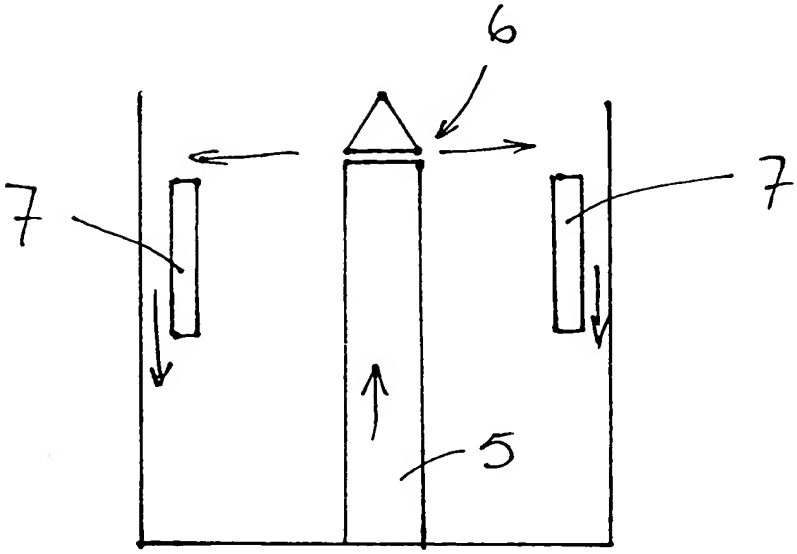

Fig 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/01108

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F23C 10/12, F23C 10/04, F23C 10/18
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F23C, F23L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	JP 4177008 A (BABCOCK HITACHI K.K.), 24 June 1992 (24.06.92) --	1-3,5-10
A	US 4766851 A (EMSPERGER ET AL), 30 August 1988 (30.08.88), figures 4,8,11 --	1,8,12
A	US 4817563 A (BEISSWENGER ET AL), 4 April 1989 (04.04.89), figures 1B,3 --	1,3,8

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
23 March 2001	27-03-2001
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

25/02/01

International application No.
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